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PATENT ABSTRACTS OF JAPAN

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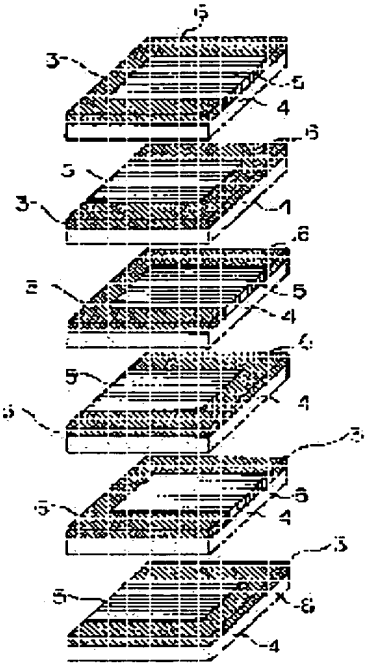
(54) STACKED PIEZOELECTRIC ACTUATOR AND MANUFACTURE THEREOF

(57)Abstract:
PURPOSE: To remove the side end of an inner electrode layer exposed at the side face so as to enable insulation, by constituting at least one of the side ends of the inner electrode exposed to the side face out of an insulator which does not interfere with the displacement when a piezoelectric actuator is displaced.
CONSTITUTION: Piezoelectric ceramics 3 and inner electrodes 5 are stacked alternately, and the inner electrodes are connected alternately to outer electrodes. Especially, the side ends of the inner electrodes 5 are constituted of insulators 6 made mainly of lead titanate so that the exposure of the inner electrodes 5 at the side face of an element, where the outer electrode connected alternately to the inner electrodes 5 are not formed, may at least alternate. And, the insulation between the inner electrodes 5 where different potentials are applied is maintained. Hereby, even in a stacked sintered substance, which has an interval between inner electrodes 5, 100μm or under, it can be insulated by removing all or selectively one pat of the side end of the exposed inner electrode 5.



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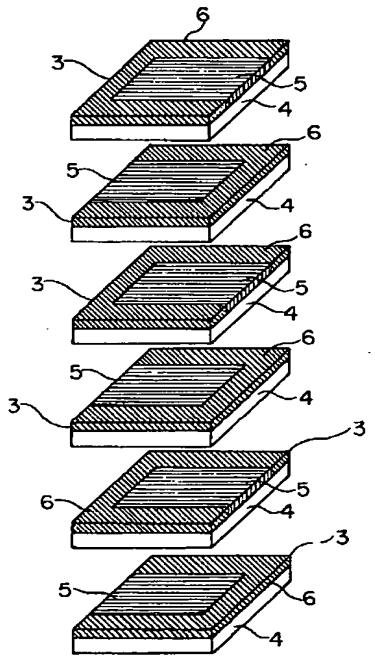
(54)【発明の名称】　積層型圧電アクチュエータおよびその製造方法

(57)【要約】
【目的】　この発明は、露出する内部電極の側端部を、全部または一部が除去されて絶縁された積層型圧電アクチュエータとその製造方法を特徴としている。
【構成】　圧電セラミックスと内部電極が交互に積層されて、内部電極が外部電極と一層置きに接続されたこの発明の積層型圧電アクチュエータは、　内部電極と一層置きに接続される外部電極が形成されない素子側面における内部電極の露出を少なくとも一層置きに成るように内部電極の側端部を、チタン酸鉛を主とする絶縁物で構成して、異なる電位が印加される内部電極間の絶縁を保つことを特徴としている。



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【特許請求の範囲】

【請求項1】　圧電セラミックスと内部電極が交互に積層され、内部電極が外部電極と一層置きに接続される積層型圧電アクチュエータにおいて、

内部電極と一層置きに接続される外部電極が形成されない素子側面における内部電極の露出を少なくとも一層置きに成るように内部電極の側端部を、チタン酸鉛を主とする絶縁物で構成して、異なる電位が印加される内部電極間の絶縁を保つことを特徴とする積層型圧電アクチュエータ。

【請求項2】　外部電極が形成されない素子両側面に露出する内部電極の両側端部を、チタン酸鉛を主とする絶縁物で構成して、異なる電位が印加される内部電極間の絶縁を保つことを特徴とする請求項1記載の積層型圧電アクチュエータ。

【請求項3】　圧電セラミックスグリーンシート上に導体ペーストを印刷して内部電極を形成し、チタン酸鉛を主とする絶縁物から成る絶縁ペーストを、外部電極が形成されない素子側面に露出する内部電極の少なくとも1つの側端部を含むよう導体ペーストと隣接するように印刷した後に、内部電極と一層置きに接続される外部電極が形成されない素子側面における内部電極の露出を少なくとも一層置きに成るように積層し、次いで、圧着、脱脂、焼成して、内部電極と外部電極を一層置きに接続することを特徴とする積層型圧電アクチュエータの製造方法。

【請求項4】　チタン酸鉛を主とする絶縁物から成る絶縁ペーストを、外部電極が形成されない素子両側面に露出する内部電極の側端部を含むよう導体ペーストと隣接して圧電セラミックスグリーンシート上に印刷したことを特徴とする請求項3記載の積層型圧電アクチュエータの製造方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】この発明は、積層型圧電アクチュエータおよびその製造方法、特に外部電極が形成されない素子側面の、内部電極が素子外部に露出する内部電極の側端部を、チタン酸鉛を主とする絶縁物で形成して成る圧電アクチュエータおよびその製造方法に関するものである。

【0002】

【従来の技術】従来、積層型圧電アクチュエータ10は、図8に示される様に内部電極層15と絶縁部分16が設けられた圧電セラミックスのグリーンシート14を図9および図10に示される如くセラミックス層13と内部電極層15とを交互に積層して、内部電極層15と外部電極17とを一層置きに接続する構造に成っている。積層型圧電アクチュエータ10は、積層型圧電アクチュエータ10の上下両端面を除く四側面を外装樹脂等で被う構造に成っているのが一般的であるが、外部電極

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17の形成されていない側面には、極性の異なる電圧が印加される内部電極層15が露出した構造に成っている。

【0003】

【発明が解決しようとする課題】積層型圧電アクチュエータ10のセラミックス層13部分がグリーンシート法などの厚膜形成法等で形成された積層型圧電アクチュエータ10は、セラミックス層13部分の厚みが100ミクロン以下と薄く、積層型圧電アクチュエータ10の素子自体の小型化、低電圧駆動が可能なデバイスとして注目されている。セラミックスは、図11に示す様にセラミックスの厚みが薄くなると単位厚み当たりに印加可能な電圧が高くなる特性がある。そのために、積層型圧電アクチュエータにおいて、セラミックス層の厚みを薄くすることによって、より大きな電界をセラミックス層に印加することが可能に成る。ところが、図10に示される様に、外部電極17の形成されていない側面に極性の異なる電圧が印加される内部電極層15が露出した構造に成っていると、外装樹脂等で側面がたとえ被覆されていても、異なる極性の電圧が印加される内部電極層15間の沿面距離はセラミックス層13の厚みしかないために、電圧が印加されると、異なる極性の電圧が印加される内部電極層15間で放電が生じて積層型圧電アクチュエータ10素子自体が破壊するという現象を生じ、積層型圧電アクチュエータ素子の製造段階で高電圧を印加する試験工程等での歩留まりが悪く、且つ信頼性が悪い等の問題点がある。特に、製造工程において、ゴミなどが付着すると、付着したゴミが微小なゴミでも、電極間間隔が100ミクロン以下と小さいために、付着した処が起点と成って内部電極層15間の放電が生じて、絶縁不良の原因と成る。

【0004】この様な内部電極層15間での絶縁不良、および放電を防ぐためには、露出した内部電極層15を無くしたり、或は露出している内部電極層15の沿面距離を長くすることが有効である。露出する内部電極層15の側端部を、全部、若しくは、選択的に一部が、機械的な方法で除去する等の方法が考えられているが、特に、セラミックス層13部分がグリーンシート法などの厚膜法で形成された積層型圧電アクチュエータ10素子は、セラミックス層13の厚みが100ミクロン以下と薄いために、内部電極層15の側面露出部分を機械的な加工法等により、除去することは困難である。また、内部電極層15の側端部を空孔にすることは、100ミクロン以下と薄いセラミックス層13を積層した構造を持つ積層型圧電アクチュエータ10では、強度的な問題が出てくる。

【0005】従って、この発明の目的は、この様な従来における問題点を解決するために、グリーンシートを積層して一体焼結することによって作成される積層型圧電アクチュエータ、特に、内部電極間隔が100ミクロン

以下の超小型の積層型圧電アクチュエータおよびその製造方法において、１００ミクロン以下の内部電極間隔を持つ積層焼結体においても露出する内部電極の側端部を、全部、若しくは、選択的に一部が除去されて絶縁された積層型圧電アクチュエータおよびその製造方法を提供することにある。

【０００６】

【課題を解決するための手段】上述の目的を達成するために、この発明は、側面に露出する内部電極の側端部の少なくとも１つを圧電アクチュエータが変位する時にその変位の妨げにならない絶縁物で構成することにより、側面に露出する内部電極層の側端部を除去して絶縁する方法、乃至は極性の異なる電圧が印加される内部電極の沿面距離を長くする方法を提案するものである。

【０００７】すなわち、この発明に依れば、圧電セラミックスと内部電極が交互に積層されて内部電極が外部電極と一層置きに接続された積層型圧電アクチュエータは、内部電極と一層置きに接続される外部電極が形成されない素子側面における内部電極の露出を少なくとも一層置きになるように内部電極の側端部を、チタン酸鉛を主とする絶縁物で構成して、異なる電位が印加される内部電極間の絶縁を保つことを特徴としている。

【０００８】また、この発明に依れば、積層型圧電アクチュエータの製造方法は、圧電セラミックスグリーンシート上に導体ペーストを印刷して内部電極を形成し、チタン酸鉛を主とする絶縁物から成る絶縁ペーストを、外部電極が形成されない素子側面に露出する内部電極の少なくとも１つの側端部を含むよう導体ペーストと隣接するように印刷した後に、内部電極と一層置きに接続される外部電極が形成されない素子側面における内部電極の露出を少なくとも一層置きに成るように積層し、次いで、圧着、脱脂、焼成して、内部電極と外部電極を一層置きに接続することを特徴としている。

【０００９】本発明者らは、先に、特願平３－１５３２１９号明細書において、外部電極と内部電極との絶縁を保ち、且つ、内部応力を緩和する部分がチタン酸鉛で構成される方法を提供しているが、この発明によれば、積層型圧電アクチュエータは、圧電セラミックスと内部電極が交互に積層され、内部電極が外部電極と一層置きに接続される積層型圧電アクチュエータにおいて、外部電極が形成されていない側面に露出する内部電極の端部を、内部電極間の沿面距離を広げ且つ絶縁を保ち且つ変位の妨げにならないように、チタン酸鉛で構成されることを特徴としている。

【００１０】更にまた、この発明に依れば、積層型圧電アクチュエータの製造方法は、圧電セラミックスグリーンシート上に導体ペーストを印刷して内部電極を形成し、チタン酸鉛を主とする絶縁物から成る絶縁ペーストを導体ペーストと隣接するように印刷した後に、積層、圧着、脱脂、焼成して、積層型圧電アクチュエータを作

成することを特徴としている。

【００１１】チタン酸鉛（$PbTiO_3$）は、積層型圧電アクチュエータに使用されるチタン酸ジルコン酸鉛（ＰＺＴ）等と同じペロブスカイト型化合物で、５００℃付近にキュリー温度を持っている。純粋なチタン酸鉛は、高温で焼結しても５００℃付近のキュリー温度を通過した時に起きる相転移による軸比の変化が大きいために、大きな内部応力が発生し、微細に破壊して焼結しない。この発明は、この現象に着目し、チタン酸鉛を、内部電極の側面に露出する側端部の絶縁部分として利用することによって構成されている。

【００１２】すなわち、内部電極の側面に露出する端部の絶縁部分として使用されるチタン酸鉛は変位を誘起するセラミックス層のチタン酸ジルコン酸鉛と同じペロブスカイト型結晶構造を持つ化合物であり、絶縁部分としてセラミックス層との馴みが良い。また、焼成時の昇温過程では、セラミックス層のチタン酸ジルコン酸鉛（ＰＺＴ）と同じ様に焼結して、焼成時の降温過程で５００℃付近のキュリー点で微細化する、特性を利用したものである。形成された絶縁部分は微細化したチタン酸鉛が入っているので、十分に絶縁を示し、且つ積層型圧電アクチュエータに電圧を印加した時に変位を拘束することがない。

【００１３】積層型圧電アクチュエータに使用される変位を誘起するセラミックスは、先に述べた様に、ペロブスカイト型構造のチタン酸ジルコン酸鉛系の化合物が殆どである。この化合物はＡサイトに鉛（Ｐｂ）を含む化合物であるが、焼成時に鉛雰囲気を調整してやらないと、Ａサイトの鉛が蒸発してセラミックスの特性に悪影響を与えるという問題がある。従って、この発明において、絶縁部分に使用されるチタン酸鉛は、その点でも同じペロブスカイト化合物であってＡサイトに鉛が入っているので、セラミックス層の鉛蒸発を抑えることができる。また、チタン酸鉛は、鉛化合物の中では、特に変位を誘起するチタン酸ジルコン酸鉛（ＰＺＴ）と比べて、安定な化合物であり、セラミックス層と反応して変位を誘起する特性に影響を与えることも少ない。

【００１４】また、絶縁部分として、使用するチタン酸鉛は、焼成時に変位を誘起する圧電セラミックスと反応しないことが必要であり、また、焼結後に、冷却過程で相転移による破砕が起きるように、軸比の変化が十分起きる程度の純度が望ましい。このためには、チタン酸鉛が、高純度であること、十分結晶化していること等が重要である。

【００１５】

【実施例】以下、実施例を挙げて、この発明の積層型圧電アクチュエータおよびその製造方法を、図を追って更に詳細に説明する。

【００１６】まず、一体焼成可能な積層型圧電アクチュエータ用材料として好適である$Pb(Zr,Ti)O_3$

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に第３成分として複合ペロブスカイト化合物を加え、ストロンチウムで変性したセラミックス粉体を、サンドミルで粉砕し１ミクロン以下の粒径にする。この粉末にバインダー、分散剤、活性剤、消泡剤を加え真空脱泡したのちドクタブレード法を用いグリーンシート４を作製する。得られたグリーンシート４の厚みは９５ミクロンであった。このグリーンシート４上に、スクリーン印刷法を用いて内部電極層５（白金）を印刷した（図１）。次に、同じグリーンシート４上に内部電極層５に隣接するように、チタン酸鉛から構成される絶縁ペーストを印刷して絶縁部分６を形成する（図２）。この絶縁部分６を形成する絶縁ペーストは、９９.９％のチタン酸鉛粉末を固形分（７０ｗｔ％）とし、エチルセルロースをバインダーとし、ブチルカルビトール、α－テルピネオールを溶剤として構成される。絶縁ペーストの印刷厚みは内部電極層５の印刷厚みを考慮した上で決定する必要がある。つまり、積層焼結体２の焼結時に同じ厚みに成る必要がある。積層圧着時や焼結時に厚みの差があると、デラミネーションやクラックの原因となる。実施例では、内部電極層５のペースト印刷厚みを１８ミクロン、絶縁部分６の層の絶縁ペースト印刷厚みを８ミクロンとした。

【００１７】次に、内部電極層５の印刷していないグリーンシート４を３０枚、内部電極層５とチタン酸鉛から構成される絶縁ペーストから成る絶縁部分６の印刷してあるグリーンシート４を図３に示す様に交互に１２０枚、更に、内部電極層５の印刷していないグリーンシート４を３０枚、積層して加熱圧着し、脱脂して、１２００℃で焼成して図４のような積層焼結体２を得た。積層焼結体２のセラミックス層３の厚みは５０ミクロン、内部電極層５とチタン酸鉛から構成される絶縁ペーストから成る絶縁部分６の厚みは共に５ミクロンであった。

【００１８】次に、この積層焼結体２の４側面を研磨し、内部電極層５とチタン酸鉛から構成される絶縁部分６の露出する相対する端面に銀ペーストを焼き付けた外部電極７を形成する。この外部電極７にリード線を半田付けし、外装を施してＷ５×Ｄ７×Ｈ９㎜の積層型圧電アクチュエータ１を得た。

【００１９】また、比較例として、図８に示す印刷パターンで印刷して、図９および図１０に示す様な従来型の構造の積層型圧電アクチュエータ１０も作製した。

【００２０】作製した積層型圧電アクチュエータ素子各々１００個に４００Ｖの電圧を５秒間印加し耐圧試験を行ったところ、この発明の第１の実施例に依る図４の様な構造を持つ積層型圧電アクチュエータ１素子が９８％の合格率であったのに対し、比較例の図９の様な従来構造の積層型圧電アクチュエータ１０素子は合格率が６３％しかなく、不良の原因は、その殆どが、異なる極性の電圧が印加される内部電極層１５間で放電が生じたゝめであった。

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【００２１】この発明に従って作製した積層型圧電アクチュエータ素子の絶縁抵抗を調べたところ１００ＭΩ以上有って十分に絶縁されていること、また、変位を測定したところ１５０Ｖで１０ミクロン以上変位して積層型圧電アクチュエータ素子として十分機能することが解かった。

【００２２】更に、この発明に従って作製した積層型圧電アクチュエータ素子に１５０Ｖ，１ｋＨｚサイン波電圧を印加して積層型圧電アクチュエータ素子を駆動させ、寿命試験を行ったところ、10^{8}回変位させても破壊は起こらず十分耐久性も有ることも解かった。

【００２３】この発明の第１の実施例では、図４に示すように外部電極７の形成されていない積層型圧電アクチュエータ素子側面に露出する内部電極層５全ての側端部をチタン酸鉛で構成された積層型圧電アクチュエータ素子を示しているが、この発明の主旨からすると、図６および図７に示す様に、極性の同じ電圧が印加される内部電極層５’のみの側端部をチタン酸鉛の絶縁部分６’で構成されるものでも同様の効果が期待される。

【００２４】

【発明の効果】以上説明したように、この発明により、１００ミクロン以下の内部電極間隔をもつ積層焼結体においても、露出する内部電極の側端部を、全部、もしくは、選択的に一部を除去して絶縁することができ、製造工程での歩留まりが良く、充分耐電圧があり、信頼性の高い積層型圧電アクチュエータ素子を製造することが出来る等の効果が得られる。

【図面の簡単な説明】

【図１】この発明の積層型圧電アクチュエータの製造工程の第１段階を示す説明図である。

【図２】この発明の積層型圧電アクチュエータの製造工程の第２段階を示す説明図である。

【図３】この発明の積層型圧電アクチュエータの製造工程の第３段階を示す説明図である。

【図４】この発明の積層型圧電アクチュエータの製造工程の第４段階を示す説明図である。

【図５】この発明の積層型圧電アクチュエータの製造工程の最終段階を示す説明図である。

【図６】この発明の積層型圧電アクチュエータの第２の実施例を示す図２に相当する説明図である。

【図７】図６の第２の実施例を示す図４に相当する説明図である。

【図８】比較例としての従来の積層型圧電アクチュエータのセラミックス層の１つを示す説明図である。

【図９】図８の従来のセラミックス層の積層を示す説明図である。

【図１０】図９の従来の積層型圧電アクチュエータを示す説明図である。

【図１１】積層型圧電アクチュエータにおける絶縁破壊電圧とセラミックス厚さの関係を示すグラフである。

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【符号の説明】

1	積層型圧電アクチュエータ
2	積層焼結体
3	セラミックス層
4	グリーンシート
5	内部電極層
5'	内部電極層
6	絶縁部分
6'	絶縁部分

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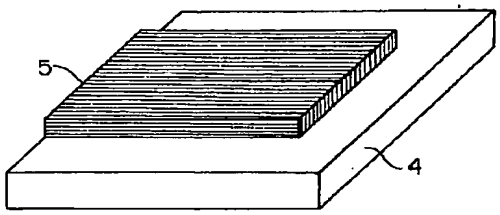
7	外部電極
１１	積層型圧電アクチュエータ
１２	積層焼結体
１３	セラミックス層
１４	グリーンシート
１５	内部電極層
１６	絶縁部分
１７	外部電極

【図１】



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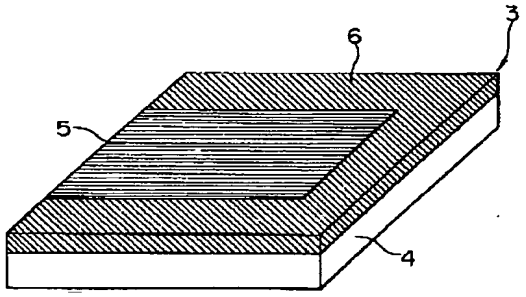

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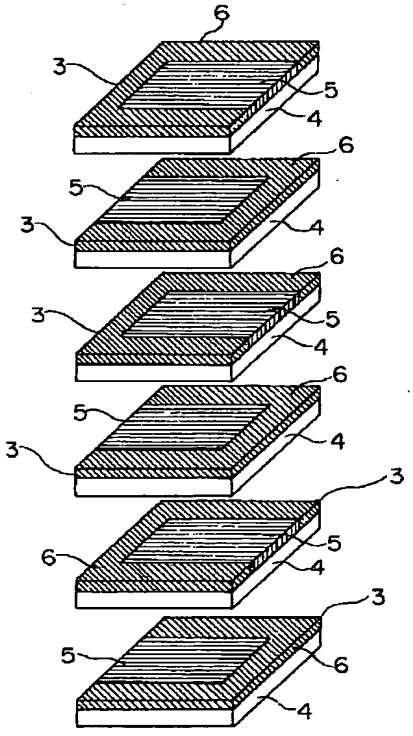

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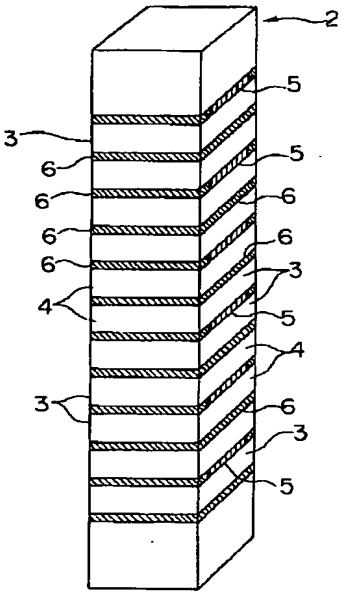

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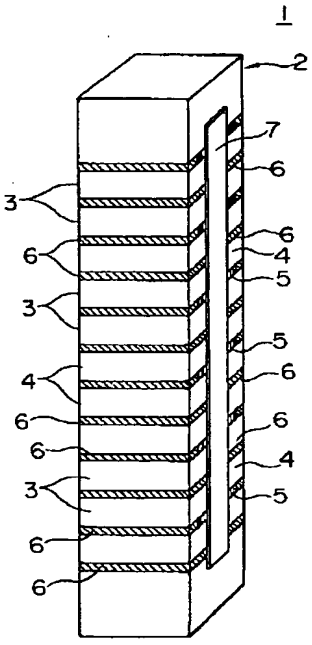

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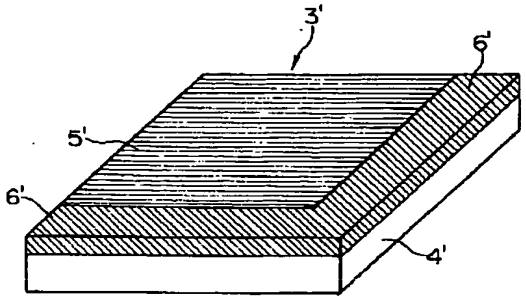

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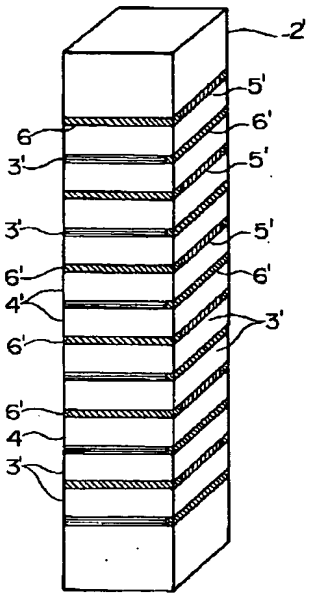

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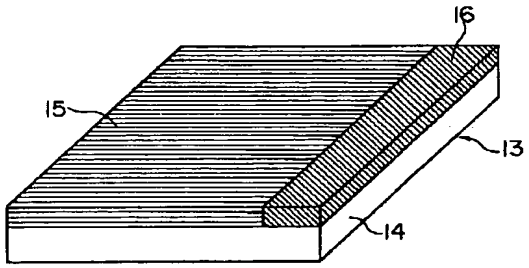

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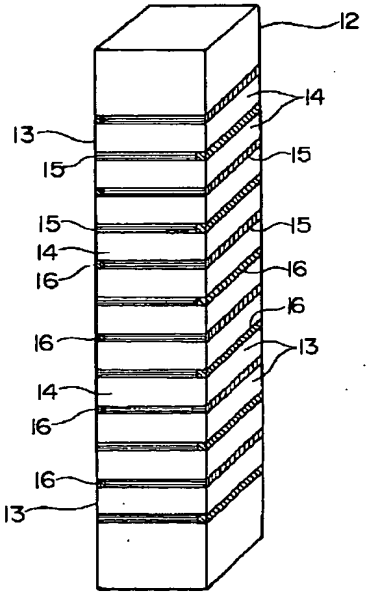

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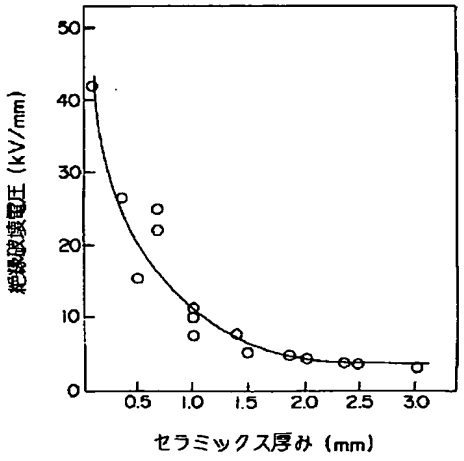

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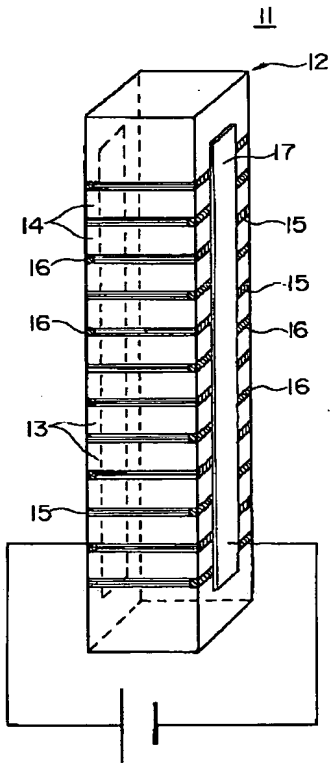

JAPANESE [JP,06-140683,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS EXAMPLE DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
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CLAIMS

[Claim(s)]
[Claim 1] In the laminating mold electrostrictive actuator by which the laminating of electrostrictive ceramics and the internal electrode is carried out by turns, and an internal electrode is connected for placing further with an external electrode The side edge section of an internal electrode is constituted from an insulating material which is mainly concerned with lead titanate so that it may change for placing further at least exposure of the internal electrode in the component side face in which the external electrode connected for placing further with an internal electrode is not formed. The laminating mold electrostrictive actuator characterized by maintaining the insulation between the internal electrodes with which different potential is impressed.
[Claim 2] The laminating mold electrostrictive actuator according to claim 1 characterized by maintaining the insulation between the internal electrodes with which the both-sides edge of the internal electrode exposed to the component both-sides side in which an external electrode is not formed is constituted from an insulating material which is mainly concerned with lead titanate, and different potential is impressed.
[Claim 3] On an electrostrictive ceramics green sheet, print conductive paste and an internal electrode is formed. After printing so that at least one side edge section of an internal electrode which exposes the insulating paste which consists of the insulating material which is mainly concerned with lead titanate to the component side face in which an external electrode is not formed may be included, and conductive paste may be adjoined A laminating is carried out so that it may change for placing further at least exposure of the internal electrode in the component side face in which the external electrode connected for placing further with an internal electrode is not formed. Subsequently The manufacture approach of the laminating mold electrostrictive actuator characterized by sticking by pressure, degreasing and calcinating and connecting an internal electrode and an external electrode for placing further.
[Claim 4] The manufacture approach of the laminating mold electrostrictive actuator according to claim 3 characterized by having adjoined conductive paste and printing on an electrostrictive ceramics green sheet so that the side edge section of an internal electrode which exposes the insulating paste which consists of the insulating material which is mainly concerned with lead titanate to the component both-sides side in which an external electrode is not formed may be included .

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the electrostrictive actuator of which the internal electrode of the component side face in which a laminating mold electrostrictive actuator and its manufacture approach, especially an external electrode are not formed forms the side edge section of the internal electrode exposed to the component exterior with the insulating material which is mainly concerned with lead titanate, and consists, and its manufacture approach.
[0002]
[Description of the Prior Art] Conventionally, the laminating mold electrostrictive actuator 10 carries out the laminating of the ceramic layer 13 and the internal electrode layer 15 by turns, as the green sheet 14 of electrostrictive ceramics which is shown in drawing 8 and with which the internal electrode layer 15 and the insulating part 16 were formed like is shown in drawing 9 and drawing 10 , and it became the structure of connecting the internal electrode layer 15 and the external electrode 17 for placing further. Although it is common to have become the structure which is wearing four side faces except the vertical both-ends side of the laminating mold electrostrictive actuator 10 by sheathing resin etc. as for the laminating mold electrostrictive actuator 10, it became the structure which the internal electrode layer 15 in which the electrical potential difference from which a polarity differs is impressed to the side face in which the external electrode 17 is not formed exposed.
[0003]
[Problem(s) to be Solved by the Invention] The laminating mold electrostrictive actuator 10 in which ceramic layer 13 part of the laminating mold electrostrictive actuator 10 was formed by the thick-film forming methods, such as the green sheet method, etc. has the thickness of ceramic layer 13 part as thin as 100 microns or less, and it is observed as a device in which the miniaturization of the component of the laminating mold electrostrictive actuator 10 itself and a low-battery drive are possible. The ceramics has the property that the electrical potential difference which can be impressed to per unit thickness becomes high, when the thickness of the ceramics becomes thin, as shown in drawing 11 . Therefore, in a laminating mold electrostrictive actuator, impressing bigger electric field to a ceramic layer changes possible by making thickness of a ceramic layer thin. However, if it became the structure which the internal electrode layer 15 in which the electrical potential difference from which a polarity differs is impressed to the side face shown in drawing 10 in which the external electrode 17 is not formed, like exposed, even if the side face is covered with sheathing resin etc. Since the creeping distance which it is between the internal electrode layers 15 to which a different polar electrical potential difference is impressed has only the thickness of the ceramic layer 13 If an electrical potential difference is impressed, discharge will arise between the internal electrode layers 15 to which a different polar electrical potential difference is impressed, and the phenomenon in which ten laminating mold electrostrictive actuators itself break will be produced. There are troubles, like the yield in the trial process which impresses the high voltage in the manufacture phase of a laminating mold electrostrictive actuator component is bad, and dependability is bad. Especially, since dust with minute adhering dust also has inter-electrode spacing as small as 100 microns or less when dust etc. adheres in a production process, the adhering place changes with an origin, and discharge between the internal electrode layers 15 arises, and it

changes with poor insulation's cause.
[0004] In order to prevent the poor insulation between such internal electrode layers 15, and discharge, it is effective to lengthen the creeping distance of the internal electrode layer 15 which loses the exposed internal electrode layer 15, or has been exposed. Although the approach of a part all removing alternatively the side edge section of the internal electrode layer 15 to expose by the mechanical approach is considered, since the thickness of the ceramic layer 13 is as thin as 100 microns or less, especially ten laminating mold electrostrictive actuators in which ceramic layer 13 part was formed by thick-film methods, such as the green sheet method, are difficult for removing the side-face exposure part of the internal electrode layer 15 by the mechanical processing method etc. Moreover, a reinforcement-problem comes out in the laminating mold electrostrictive actuator 10 in which making the side edge section of the internal electrode layer 15 into a hole has the structure which carried out the laminating of the thin ceramic layer 13 to 100 microns or less.
[0005] Therefore, in order that the purpose of this invention may solve the trouble in such the former The laminating mold electrostrictive actuator created by carrying out the laminating of the green sheet and really sintering it, especially internal electrode spacing set to a micro laminating mold electrostrictive actuator and its manufacture approach 100 microns or less. It is in offering the laminating mold electrostrictive actuator which the part was removed alternatively [or] and was insulated in the side edge section of the internal electrode exposed also in a laminating sintered compact with internal electrode spacing of 100 microns or less, and its manufacture approach.
[0006]
[Means for Solving the Problem] The approach of this invention removing the side edge section of the internal electrode layer exposed to a side face by constituting from an insulating material which does not become the hindrance of that variation rate when an electrostrictive actuator displaces at least one of the side edge sections of the internal electrode exposed to a side face, in order to attain the above-mentioned purpose, and insulating, or the approach of lengthening the creeping distance of the internal electrode with which the electrical potential difference from which a polarity differs is impressed is proposed.
[0007] If it depends on this invention, namely, the laminating mold electrostrictive actuator by which the laminating of electrostrictive ceramics and the internal electrode was carried out by turns, and the internal electrode was connected for placing further with an external electrode The side edge section of an internal electrode is constituted from an insulating material which is mainly concerned with lead titanate, and it is characterized by maintaining the insulation between the internal electrodes with which different potential is impressed so that it may become placing further at least exposure of the internal electrode in the component side face in which the external electrode connected for placing further with an internal electrode is not formed.
[0008] If it depends on this invention, moreover, the manufacture approach of a laminating mold electrostrictive actuator On an electrostrictive ceramics green sheet, print conductive paste and an internal electrode is formed. After printing so that at least one side edge section of an internal electrode which exposes the insulating paste which consists of the insulating material which is mainly concerned with lead titanate to the component side face in which an external electrode is not formed may be included, and conductive paste may be adjoined A laminating is carried out so that it may change for placing further at least exposure of the internal electrode in the component side face in which the external electrode connected for placing further with an internal electrode is not formed, and it is characterized by sticking by pressure, degreasing and calcinating and subsequently, connecting an internal electrode and an external electrode for placing further.
[0009] Although this invention persons offer the approach by which the part which maintains the insulation with an external electrode and an internal electrode, and eases internal stress in a Japanese-Patent-Application-No. No. 153219 [three to] specification previously consists of lead titanates According to this invention, a laminating mold electrostrictive actuator In the laminating mold electrostrictive actuator by which the laminating of electrostrictive ceramics and the internal electrode is carried out by turns, and an internal electrode is connected for placing further with an external electrode It is characterized by consisting of lead titanates so that the creeping distance between internal electrodes may be extended for the edge of the internal electrode exposed to the side face in which the external electrode is not formed, an insulation may be maintained and it may

not become the hindrance of a variation rate.
[0010] Furthermore, if it depends on this invention, on an electrostrictive ceramics green sheet, the manufacture approach of a laminating mold electrostrictive actuator prints conductive paste, forms an internal electrode, and after it prints the insulating paste which consists of the insulating material which is mainly concerned with lead titanate so that conductive paste may be adjoined, it is characterized by the laminating and sticking by pressure, degreasing and calcinating and creating a laminating mold electrostrictive actuator again.
[0011] Lead titanate (PbTiO3) is the same perovskite mold compound as the titanic-acid lead zirconate (PZT) used for a laminating mold electrostrictive actuator, and has Curie temperature near 500 degree C. Since change of the axial ratio by the phase transition which occurs when the Curie temperature near 500 degree C is passed, even if it sinters at an elevated temperature is large, big internal stress occurs, it destroys minutely and pure lead titanate is not sintered. This invention is constituted by using lead titanate paying attention to this phenomenon as an insulating part of the side edge section exposed to the side face of an internal electrode.
[0012] That is, the lead titanate used as an insulating part of the edge exposed to the side face of an internal electrode is a compound with the same perovskite mold crystal structure as the titanic-acid lead zirconate of the ceramic layer which carries out induction of the variation rate, and its **** with a ceramic layer is good as an insulating part. Moreover, in the temperature up process at the time of baking, it sinters like the titanic-acid lead zirconate (PZT) of a ceramic layer, and the property made detailed in the Curie point near 500 degree C in the temperature fall process at the time of baking is used. Since the lead titanate made detailed is contained, the formed insulating part does not restrain a variation rate, when an insulation is fully shown and an electrical potential difference is impressed to a laminating mold electrostrictive actuator.
[0013] The compound of the titanic-acid lead zirconate system of perovskite type structure is almost the case at the appearance which described previously the ceramics which carries out induction of the variation rate used for a laminating mold electrostrictive actuator. Although this compound is a compound which contains lead (Pb) to A site, if a lead ambient atmosphere is not adjusted at the time of baking, there is a problem of the lead of A site evaporating and having a bad influence on the property of the ceramics. Therefore, in this invention, since it is the same perovskite compound and lead is contained in A site also at that point, the lead titanate used for an insulating part can suppress lead evaporation of a ceramic layer. Moreover, in a lead compound, compared with the titanic-acid lead zirconate (PZT) which carries out induction of the variation rate, especially lead titanate is a stable compound and it is also rare to affect the property which reacts with a ceramic layer and carries out induction of the variation rate.
[0014] Moreover, as an insulating part, the lead titanate to be used needs not to react with the electrostrictive ceramics which carries out induction of the variation rate at the time of baking, and the purity whose change of an axial ratio is extent which occurs enough is desirable [lead titanate] so that crushing by phase transition may break out by the cooling process after sintering. For that, it is important that lead titanate is a high grade, to crystallize enough, etc.
[0015]
[Example] Hereafter, an example is given and drawing is further explained to a detail for the laminating mold electrostrictive actuator and its manufacture approach of this invention later on.
[0016] First, a perovskite type complex compound is added to Pb(Zr, Ti) O3 [suitable as a charge of laminating mold electrostrictive actuator material which can really be calcinated] as the 3rd component, and the ceramic fine particles which denaturalized with strontium are ground by the sand mill, and are made into the particle size of 1 micron or less. After adding and carrying out vacuum degassing of a binder, a dispersant, an activator, and the defoaming agent to this powder, a green sheet 4 is produced using the doctor blade method. The thickness of the obtained green sheet 4 was 95 microns. On this green sheet 4, screen printing was used and the internal electrode layer 5 (platinum) was printed (drawing 1). Next, the insulating paste which consists of lead titanates is printed, and an insulating part 6 is formed so that the internal electrode layer 5 may be adjoined on the same green sheet 4 (drawing 2). The insulating paste which forms this insulating part 6 makes 99.9% of lead titanate powder solid content (70wt%), and uses ethyl cellulose as a binder, and butyl carbitol and alpha-terpineol are constituted as a solvent. After taking into consideration the printing

thickness of the internal electrode layer 5, it is necessary to determine the printing thickness of an insulating paste. That is, it is necessary to grow into the thickness same at the time of sintering of the laminating sintered compact 2. If there is a difference of thickness at the time of laminating sticking by pressure and sintering, it will become the cause of delamination or a crack. In the example, 18 microns and insulating paste printing thickness of the layer of an insulating part 6 were made into 8 microns for the paste printing thickness of the internal electrode layer 5.

[0017] Next, as the green sheet 4 with which 30 sheets, the internal electrode layer 5, and the insulating part 6 that consists of the insulating paste which consists of lead titanates are printed in the green sheet 4 which is not printing the internal electrode layer 5 was shown in drawing 3 , by turns, the laminating of the 30 green sheets 4 which are not printing the internal electrode layer 5 was carried out, they carried out heating sticking by pressure further 120 sheets, and it degreased, and it calcinated at 1200 degrees C, and a laminating sintered compact 2 like drawing 4 was obtained. Both the thickness of the insulating part 6 to which the thickness of the ceramic layer 3 of the laminating sintered compact 2 changes from the insulating paste with which it consists of 50 microns, an internal electrode layer 5, and lead titanate was 5 microns.

[0018] Next, four side faces of this laminating sintered compact 2 are ground, and the external electrode 7 which was able to be burned on the end face which the internal electrode layer 5 and the insulating part 6 which consists of lead titanates expose, and which faces in the silver paste is formed. Lead wire was soldered to this external electrode 7, sheathing was performed, and the W5xD7xH9mm laminating mold electrostrictive actuator 1 was obtained.

[0019] Moreover, it printed as an example of a comparison by the printing pattern shown in drawing 8 , and the laminating mold electrostrictive actuator 10 of the structure of a conventional type as shown in drawing 9 and drawing 10 was also produced.

[0020] when the electrical potential difference of 400V is impressed to the produced laminating mold electrostrictive actuator components of 100 each for 5 seconds and a compressive test is performed As opposed to one laminating mold electrostrictive actuator with structure like drawing 4 which depends on the 1st example of this invention having been 98% of rate of success Conventionally like drawing 9 of the example of a comparison, there was no rate of success, and as for a defect's cause, discharge arose between the internal electrode layers 15 to which the polar electrical potential difference from which the most differs is impressed, and it was [only 63% of ten laminating mold electrostrictive actuators of structure] eye ****.

[0021] It is ******** to displace 10 microns or more and to function enough as a laminating mold electrostrictive actuator component by 150V, when there being 100 M omega or more and fully insulating, when the insulation resistance of the laminating mold electrostrictive actuator component produced according to this invention is investigated, and a variation rate are measured.

[0022] Furthermore, it is also ******** that destruction does not take place even if it carries out a variation rate 108 times, when impress a 150V or 1kHz sine wave electrical potential difference to the laminating mold electrostrictive actuator component produced according to this invention, a laminating mold electrostrictive actuator component is made to drive and life test is performed, but there is also endurance enough.

[0023] the internal electrode layer 5 exposed to the laminating mold electrostrictive actuator component side face in which the external electrode 7 is not formed in the 1st example of this invention as shown in drawing 4 , although the laminating mold electrostrictive actuator component which consisted of lead titanates in all the side edge section is shown Considering the main point of this invention, the same effectiveness is expected also by what consists of insulating part 6' of lead titanate in the side edge section of only internal electrode layer 5' to which the same polar electrical potential difference is impressed to be shown in drawing 6 and drawing 7 .

[0024]

[Effect of the Invention] As explained above, by this invention, a part can all be removed alternatively, the side edge section of the internal electrode exposed also in a laminating sintered compact with the internal electrode spacing of 100 microns or less can be insulated, the yield in a production process is good, there is withstand voltage of enough, and the effectiveness of being able to manufacture a reliable laminating mold electrostrictive actuator component is acquired.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the explanatory view showing the 1st step of the production process of the laminating mold electrostrictive actuator of this invention.
[Drawing 2] It is the explanatory view showing the 2nd step of the production process of the laminating mold electrostrictive actuator of this invention.
[Drawing 3] It is the explanatory view showing the 3rd step of the production process of the laminating mold electrostrictive actuator of this invention.
[Drawing 4] It is the explanatory view showing the 4th step of the production process of the laminating mold electrostrictive actuator of this invention.
[Drawing 5] It is the explanatory view showing the culmination of the production process of the laminating mold electrostrictive actuator of this invention.
[Drawing 6] It is an explanatory view equivalent to drawing 2 which shows the 2nd example of the laminating mold electrostrictive actuator of this invention.
[Drawing 7] It is an explanatory view equivalent to drawing 4 which shows the 2nd example of drawing 6 .
[Drawing 8] It is the explanatory view showing one of the ceramic layers of the conventional laminating mold electrostrictive actuator as an example of a comparison.
[Drawing 9] It is the explanatory view showing the laminating of the conventional ceramic layer of drawing 8 .
[Drawing 10] It is the explanatory view showing the conventional laminating mold electrostrictive actuator of drawing 9 .
[Drawing 11] It is the graph which shows the relation between the dielectric breakdown voltage in a laminating mold electrostrictive actuator, and ceramic thickness.
[Description of Notations]
1 Laminating Mold Electrostrictive Actuator
2 Laminating Sintered Compact
3 Ceramic Layer
4 Green Sheet
5 Internal Electrode Layer
5' Internal electrode layer
6 Insulating Part
6' Insulating part
7 External Electrode
11 Laminating Mold Electrostrictive Actuator
12 Laminating Sintered Compact
13 Ceramic Layer
14 Green Sheet
15 Internal Electrode Layer
16 Insulating Part
17 External Electrode

[Translation done.]